Northern Rocky Mountain Science Center
U.S. Department of the Interior
Geological Survey

Using Fine Scale Analysis to Asses the Potential Impacts of Climate Change on Native Salmonids in the Northern Rockies

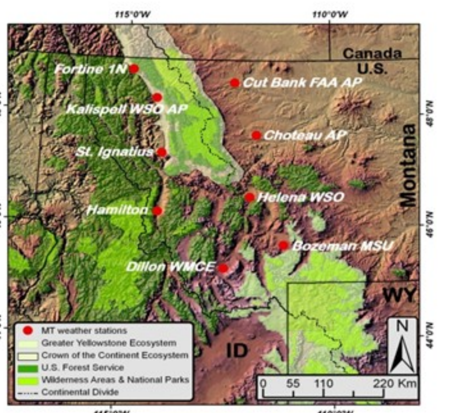
Approach

In order to fully understand the impacts of climate change on aquatic resources at multiple spatial scales, the team will implement the second phase of the project in 2009, which will assess the utility of coarse-grained, large scale models of climate impacts versus finer-grained approaches to "downscale" climate impacts. This multi-scale approach will provide resource managers with the necessary information to develop stream or drainage-specific habitat and fish management programs to mitigate for climate change.

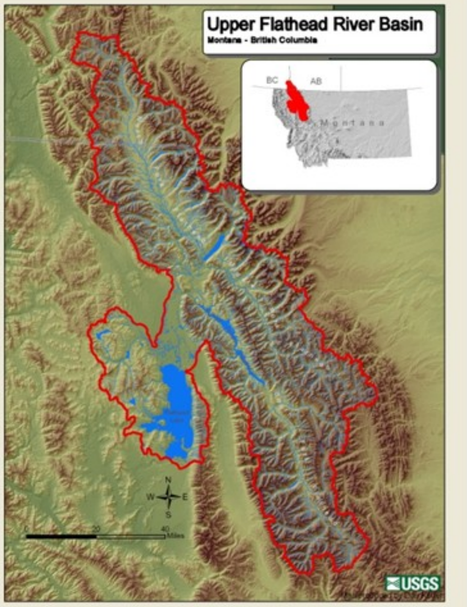
Repeat photographs of Boulder Glacier depicting 97 years of change.

This study will predict how native fish distributions and life histories may be modified under various warming climate scenarios in the upper Flathead River drainage. This information may be used by managers to develop pro-active conservation measures to maintain and protect native bull trout and westslope cutthroat trout populations. Fine-scale analyses will focus on systems with higher-resolution data at reach and stream scales. Data include downscaled GCM runs, current and historic water and air temperatures, stream flows, precipitation, fire regimes, and fish species distributions. The focal Salmonid species of this study are the threatened bull trout and the westslope cutthroat trout, both of which are highly sensitive to elevated temperatures.

This study will: (1) synthesize current data on the distribution and temperature requirements of native bull and cutthroat trout; (2) compile all current and historic data for water temperature, air temperature, flow and precipitation, and their relationships to elevation, basin area, vegetation, and wildfire regime etc. in each stream and watershed; (3) assess the relationship of these factors and the distribution (occurrence) of native salmonids; (4) map the current fish distributions, temperatures and habitats in a GIS framework ; (5) explore the distributions of thermally suitable habitat for each species and life history type under warming climate scenarios (50, 100, 150 and 300 years); (6) identify populations and species that are at greater risk of extirpation in the face of climate change; and (7) assess the future effects of invasive aquatic species.



Map of western Montana showing weather stations used in this study, sensitive ecosystems associated with National Parks, and other protected federal lands.

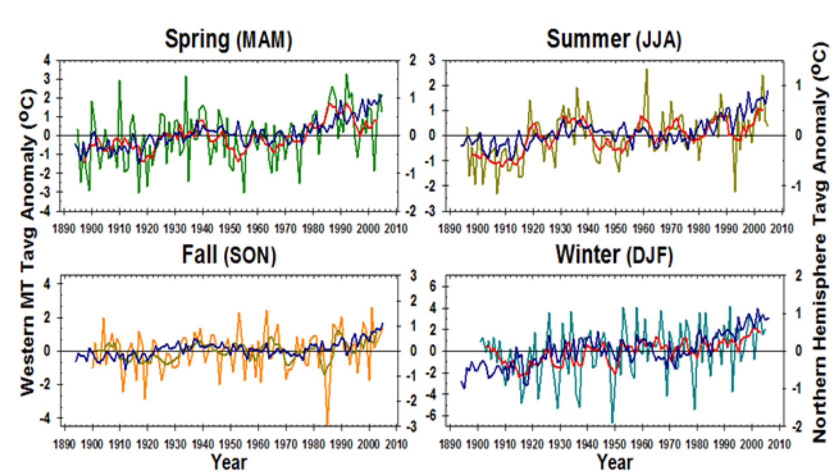


Study area for the fine-scale analysis in the upper Flathead River drainage, Montana (USA) and British Columbia (Canada).

These results will be contrasted with two other fine-scale studies that the team is working on in the west (Idaho and Colorado) to compare climate impacts among and within salmonid species across broad geographic areas in the western United States. Additional sub-species with significant data for conducting fine-scale analyses potentially include the Rio Grande cutthroat trout and Gila trout.

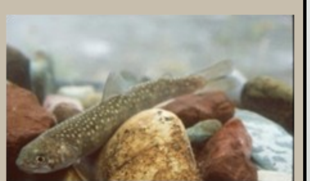
Air Temperatures:

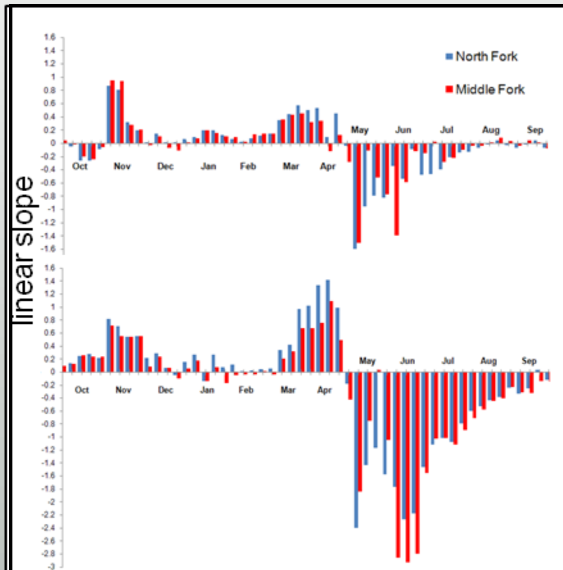
We are analyzing over 100 years of daily and monthly temperature data collected in western Montana, USA for long-term changes in seasonal averages and daily extremes. The long-term climatic trends in western Montana are consistent with other studies of mountains in the temperate zone. Significant trends in daily and seasonal temperature resemble the more rapid warming occurring at high latitudes and across heavily forested regions. Annual and seasonal temperature variability tracks Global and Northern Hemisphere trends on short- (interannual) and long-term (multi-decadal and greater) scales. Western Montana has thus far experienced a +1.33°C (1900-2006) rise in annual average temperatures, which is 1.8 times greater than the +0.74°C (1900-2005) rise in Global temperatures.



Comparison between trends in western Montana and Northern Hemisphere (blue line) seasonal temperatures. Red line displays the western Montana 5-year running mean. Note change in scale of temperature axis for each season, this has implications related to absolute temperature change.

Native westslope cutthroat trout (below left) and bull trout (below right), persisting in the Crown of the Continent Ecosystem for ~11,000-14,000 years, have one of the coldest temperature requirements among inland salmonids species.



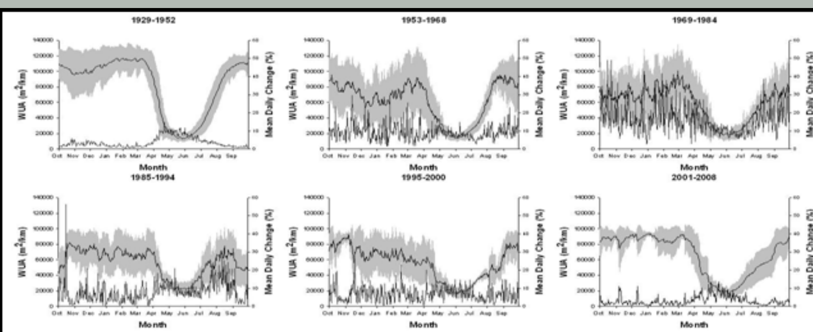


Discharge trends from 1940 - 2008 (top) and 1970 – 2008 (bottom) for the North Fork and Middle Fork of the Flathead River. Each bar represents the linear slope value for each weekly mean discharge dataset with a time course by year.

Stream Discharge:

Mean temperature fluctuations typically impact early and late winter the greatest. A warmer than average year generally shifts the precipitation ratio of rain to snow days towards rain and increases the chance of rain on snow events similar to the Nov. 2006 event in Glacier National Park. Regression curve estimations indicate that mean discharge has increased from 1940 to 2008 for late fall, winter, and early spring, with the highest increase occurring during the bounding months of the winter season.

Effects of climate change on stream temperature, basin storage and stream discharge are quantified. Physical stream and basin metrics are included as an integral part of the study as the magnitude of the hydrologic response to simulated climate change is highly dependent on basin morphology and geological setting of the area. Flow accumulation variables furnish pour point discharge and flow duration curves applicable for use in an integrated multivariate habitat suitability output. Air temperatures (min, max, mean) from a given day and the 5 days prior due to the lag in heat transfer and derived discharge values will be analyzed to identify water temperature impacts using multiple regression and ANOVA.

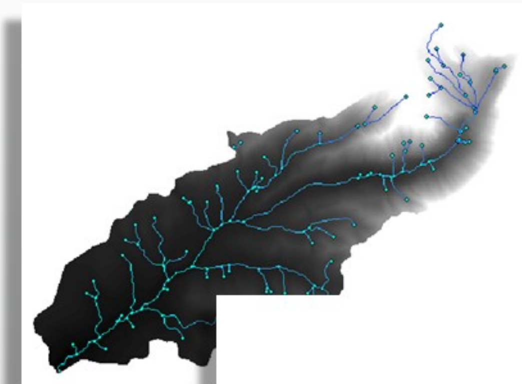


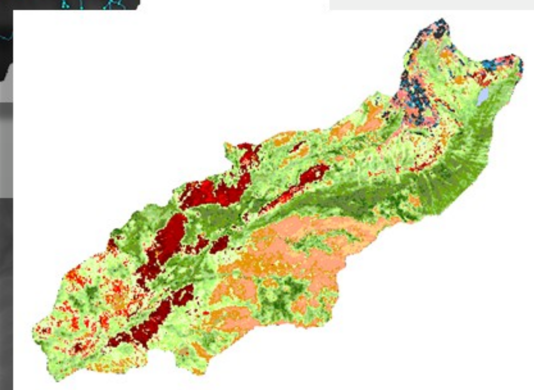
GIS and Modeling Framework:

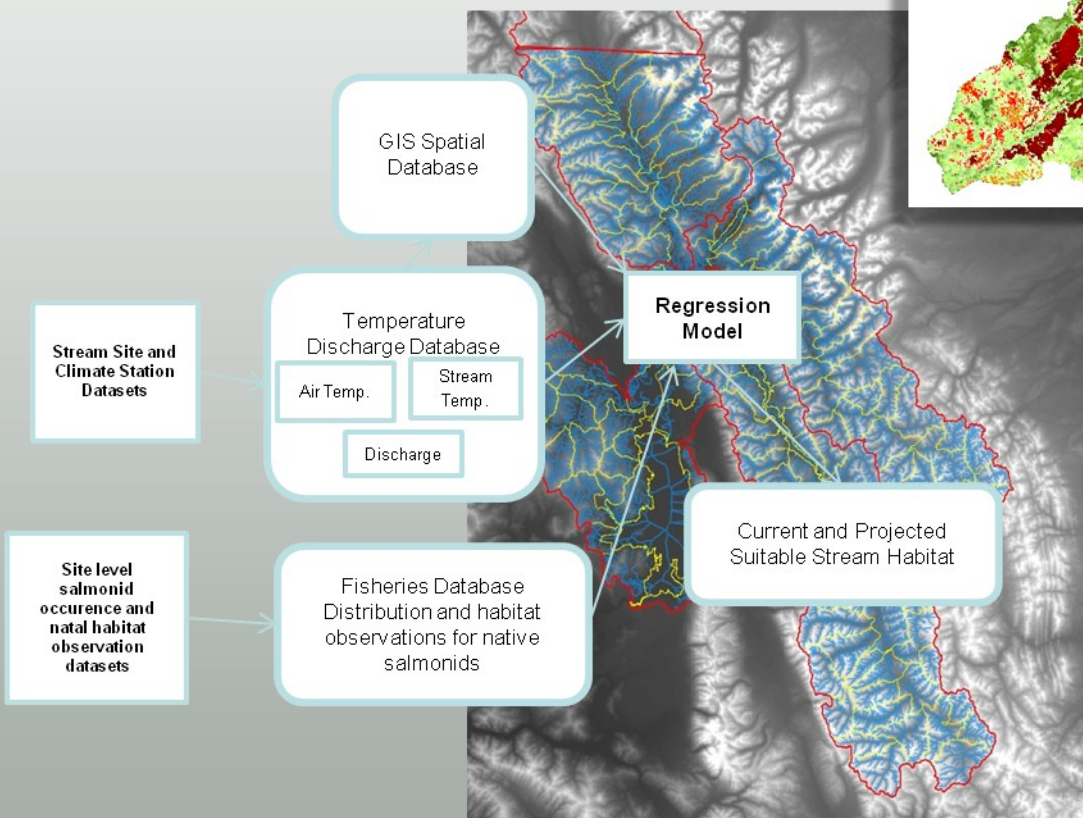
A geographic information system (GIS) based approach provides a framework for understanding and addressing the scope of climate change impacts on native aquatic ecosystem in a holistic manner.

Extraction of stream network and watershed characteristics from a digital elevation model (DEM) will be performed across the study area in each sub watershed allowing a raster and vector stream network spatially co-registered to the DEM to be available for basin morphometry and relief characteristics for integration into a modeling fabric in a GIS. Feature classes, topology, and the geometric network are related inside a geodatabase managing raster datasets and facilitating the modeling framework and link to external tables performing multiple regression and statistical functions. Products include:

- Downscaled regional GCM scenarios calibrated with local climate stations to develop current air temperature and precipitation datasets
- Magnitude and timing of historic and future discharge at flow accumulation pour points
- Temperature attributed grid and vector stream network
- Historic and future subwatershed spatial storage variables
- Comparison of model runs (DHSVM, PRSM, in house etc) in subwatersheds to illustrate model uncertainty







Salmonids are often considered a keystone species for aquatic and terrestrial ecosystems, and may be an especially important indicator of ecosystem health in the face of climate change. They provide an excellent early warning indicator of climate warming because their body temperature is dependent on the temperature of their surroundings, and they have characteristically narrow tolerances of thermal fluctuation.

For more information contact:

Clint Muhlfeld, Aquatic Ecologist
Phone: 406-888-7926
Email: cmuhlfeld@usgs.gov

Dan Kotter, Biological Research Technician
Phone: 406-888-7920
dan_kotter@nps.gov

The Northern Rocky Mountain Science Center is located in Bozeman, Montana and includes three field stations in Montana and one duty station in Wyoming. For more information on NOROCK's research, please visit http://nrmsc.usgs.gov or contact the Center Director: Jeff Kershner 406-994-5304 or jkershner@usgs.gov